MILLIMETER WAVE SPECTROSCOPY OF ROCKS AND FLUIDS

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One region of the electromagnetic spectrum that is relatively unexploited for materials characterization is the millimeter wave band (frequencies roughly between 40 and 300 GHz). Millimeter wave techniques involve free-space (non-contacting) measurements which have a length scale that makes them ideal for characterizing bulk properties of multicomponent composites where the scale of homogeneity is on the order of millimeters. These composites include granular materials such as rocks, fluid mixtures, suspensions and emulsions.

In this talk we will show data on partially saturated rocks and an oil/water mixture which demonstrate that millimeter wave spectroscopy is a sensitive, yet rapid measure of changing composition. The sensitivity of the dielectric permittivity to the moisture content make millimeter wave techniques idea for characterizing water content. In addition, we will show how dielectric anisotropy can be related to the mesoscopic structure of the sample.

The measurements are performed in a quasi-optical setup with state-of-the-art vector network analyzer. The millimeter waves are generated by a sweepable centimeter wave source (i.e., microwaves; in this case from 8-18 GHz). These centimeter waves are harmonically multiplied by Schottky diodes, coupled into waveguide and eventually radiated into free space by a scalar horn antenna. A polyethylene lens focuses the beam and a sample is placed in the focal plane. The transmitted field is then collected by an identical lens/horn combination, detected by another Schottky harmonic detector and fed to a vector receiver which mixes the centimeter waves down to more easily manageable frequencies where the signal is digitized. Reflected waves are also collected by the transmitting horn and routed via a circulator and isolator to the vector receiver. The source and receiver oscillators are phase-locked. The experiments described here were performed in the W band (nominally 75-110 GHz); other bands are readily accessible by changing waveguides and sources/detectors.